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Effect of Wrapping Materials and Cold Storage Durations on Firmness of Plum

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Abstract: Three wrapping materials (kraft paper + straw, kraft paper and news paper) and five cold storage durations (0, 8, 16, 24 and 32-day) were investigated for firmness of plum (cv. Shablon) during cold storage at-1°C temperature and 98% relative humidity. The experiment was laid out in Factorial Completely Randomized Design (FCRD) with four replications for each one of factors. The data collected were subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) at 1% probability was performed to compare the means of different treatments. The statistical results of the study indicated that wrapping material and cold storage duration significantly ($P \leq 0.01$) affected firmness of plum. Results of the study also indicated that firmness decreased by increasing cold storage duration. In addition, kraft paper + straw was the best wrapping materials for keeping firmness.

Key words: Plum · Wrapping Material · Cold Storage Duration · Firmness

INTRODUCTION

Plums come in a wide variety of colors and sizes. Some are much firmer-fleshed than others and some have yellow, white, green or red flesh, with equally varying skin color [1]. They are produced around the world and China is the world's largest producer. The ten largest producers of plums are China, Romania, USA, Serbia, Chile, France, Iran, Turkey, Italy and India. Iran products nearly about 269,139 tons of plum and is ranked 7th in the world [2]. But, Iranian plums are not exported because of variability in size and shape and lack of suitable packaging [3].

Methods that are being used to preserve whole fruits and vegetables during storage and marketing are generally based on refrigeration with or without control of composition of the atmosphere [4, 5]. However, temperature, atmosphere, relative humidity and sanitation must be regulated to maintain quality of them [6, 7]. In this direction, several methods that have been used are refrigeration, controlled atmosphere packaging, modified atmosphere packaging and chemical preservatives [8-10]. The most prevalent method is rapid cooling at a low temperature with high relative humidity [11]. However, low temperature storage is not economically feasible in most developing countries [5, 12].

Fungicides control postharvest decay of whole fruits, but they leave residues that are potential risks to humans and the environment [12]. In addition, many consumers are suspicious of chemicals in their foods, especially in fruits and vegetables [9]. Sulfites were effective chemical preservative as they were both inhibitors of enzymatic browning and antimicrobial. But their use has been banned due to adverse reaction in consumers [9, 13]. Moreover, chemical preservatives affect the flavor of fruits and vegetables [14].

Coatings, films and wrapping materials are also effective in reducing desiccation (moisture loss), but are subject to microbial growth and disposal problems [10, 15]. Many years of research are conducted to develop a material that would cover fruit so that an internal modified atmosphere would develop [16, 17].

In this paper, the effect of wrapping material and cold storage duration on firmness of plum (cv. Shablon) during cold storage at-1°C temperature and 98% relative humidity is reported.

MATERIALS AND METHODS

Plant Materials: Plums (cv. Shablon) were purchased from a local market in Karaj, Iran. They were visually

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Fig. 1: Handheld fruit penetrometer or fruit firmness tester

inspected for freedom of defects and blemishes. Plums were then wrapped in different wrapping materials (kraft paper + straw, kraft paper and news paper), placed in plastic boxes and stored in cold storage at-1°C temperature and 98% relative humidity for 0, 8, 16, 24 and 32 days.

Firmness: The firmness of plums was measured using a handheld fruit penetrometer or fruit firmness tester (Fig. 1). The penetrometer had a diameter of 8.0 mm and the maximum pressure measured during each test based on kg cm^{-2} was considered as stiffness.

Statistical Analysis: The experiment was laid out in Factorial Completely Randomized Design (FCRD) with three wrapping materials (kraft paper + straw, kraft paper and news paper) and five cold storage durations (0, 8, 16, 24 and 32-day) at-1°C temperature and 98% relative humidity with four replications for each one of factors. The effect of the factors on firmness was determined by analysis of variance (ANOVA) using SPSS 12.0 (Version, 2003). Also, Duncan's Multiple Range Test (DMRT) at 1% probability was performed to compare the means of different treatments.

RESULTS AND DISCUSSION

Wrapping material and cold storage duration significantly ($P \leq 0.01$) affected firmness of plum (Table 1). The highest firmness of 11.16 kg/cm^2 was observed in kraft paper + straw and lowest (10.21 kg/cm^2) in news paper and wrapping material affected firmness in the order of kraft paper + straw > kraft paper > news paper. Also, the highest firmness of 12.70 kg/cm^2 was observed in 0-day and lowest (8.337 kg/cm^2) in 32-day and firmness decreased with increased cold storage duration (Table 2). Moreover, interaction of wrapping material × cold storage duration had no significant effect ($P \leq 0.01$) on firmness (Table 1). The study of wrapping material and cold storage duration combinations on firmness indicated that in each wrapping material, firmness had the highest value in 0-day and the lowest value in 32-day. In addition, the maximum mean value for firmness (12.70 kg/cm^2) was observed in 0-day of three wrapping materials and the minimum mean value for firmness (7.828 kg/cm^2) was observed in 32-day of news paper (Table 3). These results are in agreement with those of

Table 1: Analysis of variance for firmness of plum (cv. Shablon)

Source of variation	Degree of freedom	Mean square
Wrapping material	2	5.90 **
Cold storage duration	4	44.9 **
Wrapping material × Cold storage duration	8	0.71 ns
Error	45	1.10
C.V. (%)	---	9.68

** = Significant at 0.01 probability level
ns = Non-significant

Table 2: Means comparison for firmness of plum (cv. Shablon) for different studied treatments using DMRT at 1% probability

	Treatment	Firmness (kg/cm^2)
Wrapping material	Kraft paper + straw	11.16 a
	Kraft paper	11.14 a
	News paper	10.21 b
Cold storage duration	0-day	12.70 a
	8-day	12.33 ab
	16-day	11.57 b
	24-day	9.261 c
	32-day	8.337 d

Means in the same column with different letters differ significantly at 0.01 probability level according to DMRT

Table 3: Means comparison for firmness of plum (cv. Shablon) for combinations of wrapping material and cold storage duration using DMRT at 1% probability

Wrapping material × Cold storage duration		Firmness (kg/cm^2)
Kraft paper + straw	0-day	12.70 a
	8-day	12.65 a
	16-day	12.41 a
	24-day	9.428 cde
	32-day	8.625 de
Kraft paper	0-day	12.70 a
	8-day	12.61 a
	16-day	11.97 a
	24-day	9.885 cd
	32-day	8.558 de
News paper	0-day	12.70 a
	8-day	11.73 ab
	16-day	10.33 c
	24-day	8.470 de
	32-day	7.828 e

Means in the same column with different letters differ significantly at 0.01 probability level according to DMRT

Lerdthanangkul and Krochta [15], Rashidi *et al*. [18] and Rashidi *et al.* [19] who concluded that coatings, films and wrapping materials significantly affected firmness. These results are also in line with the results reported by Mostofi and Toivonen [7], Rashidi *et al*. [18] and Rashidi *et al*. [19] that firmness significantly decreased by increasing cold storage duration.

CONCLUSION

Wrapping material and cold storage duration significantly ($P \leq 0.01$) affected firmness of plum. Results of the study also indicated that firmness decreased by increasing cold storage duration. In addition, kraft paper + straw was the best wrapping materials for keeping firmness.

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